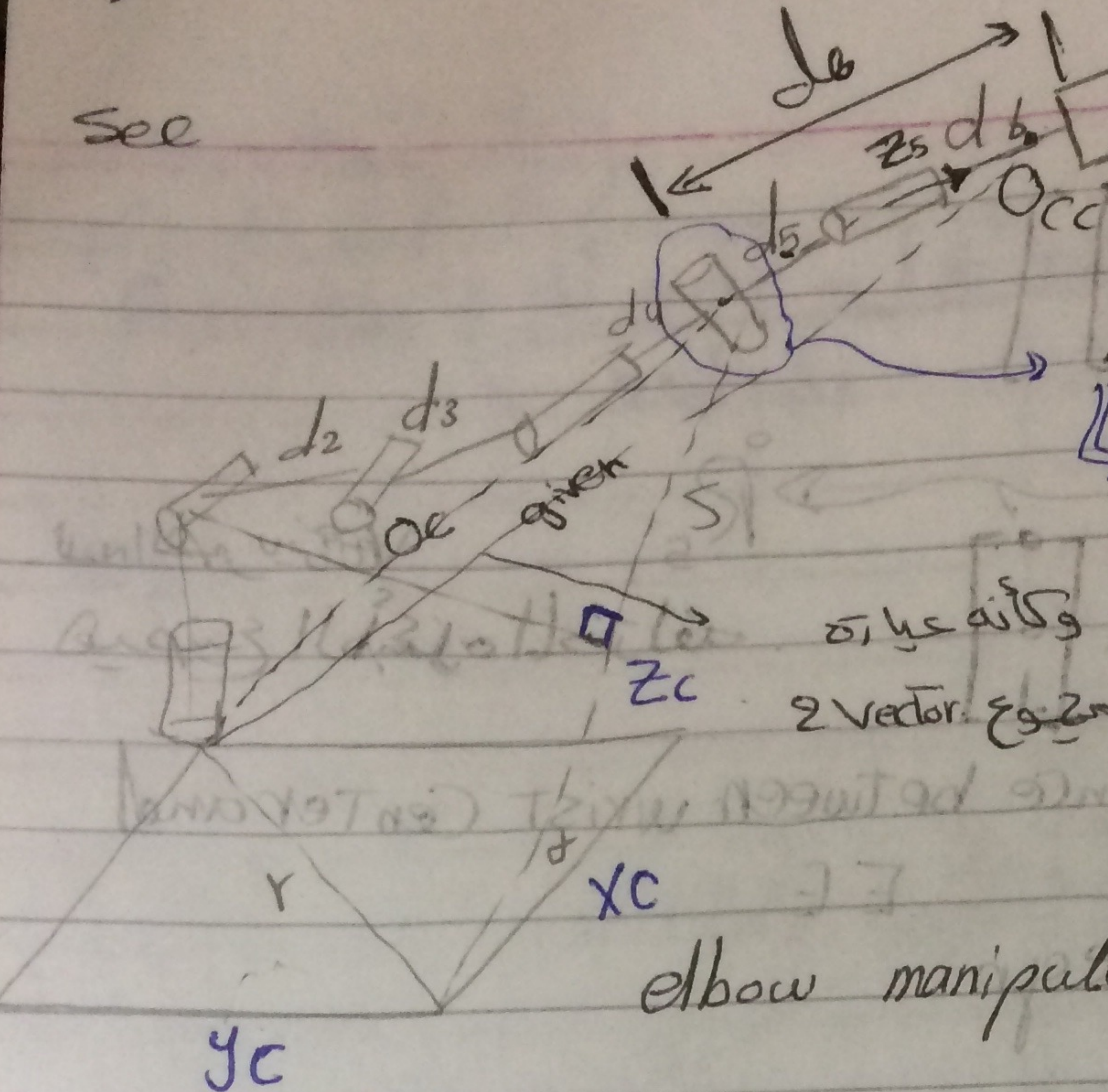
١٣ شوال

Robotics.

See



ولتحديد 2 زوايا أساس
أول ٣ زوايا

spherical wrist.

"نقدر نستخدم طريقة نحسب أول 3 Angle"
for 3 first Joint".

closed form :: " Kinematic Decupling "

steps ⟶

* given :- O_{EE} " position of endeffector, rotation "

$$R_{EE} \longrightarrow H_{EE}^{base}$$

* Required : q_k " ex: elbow ⇒ $\theta_1 \longrightarrow \theta_6$ "

* Algorithm :-

1. $O_c = O_{EC}$" given " $- \ d_6 R_5^0 \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

wrist center.

$$\begin{bmatrix} C30 & -S30 & 0 \\ S30 & C30 & 0 \\ 0 & 0 & 1 \end{bmatrix} * \begin{bmatrix} C20 & -S20 & 0 \\ S20 & C20 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} C50 & -S50 & 0 \\ S50 & C50 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$^{0}R_{6} \quad R_{EE}$

$$\left[\;[\;]\;\right]\left[\;[\;]\;\right] = {}^{0}R_{5}$$

لان الصفر لابن Vector
هيمتنع الأجزاء المختلفة.

$$O_c = O_{EE} - \underbrace{d_6}_{\text{distance between wrist center and EE}} R_{EE} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

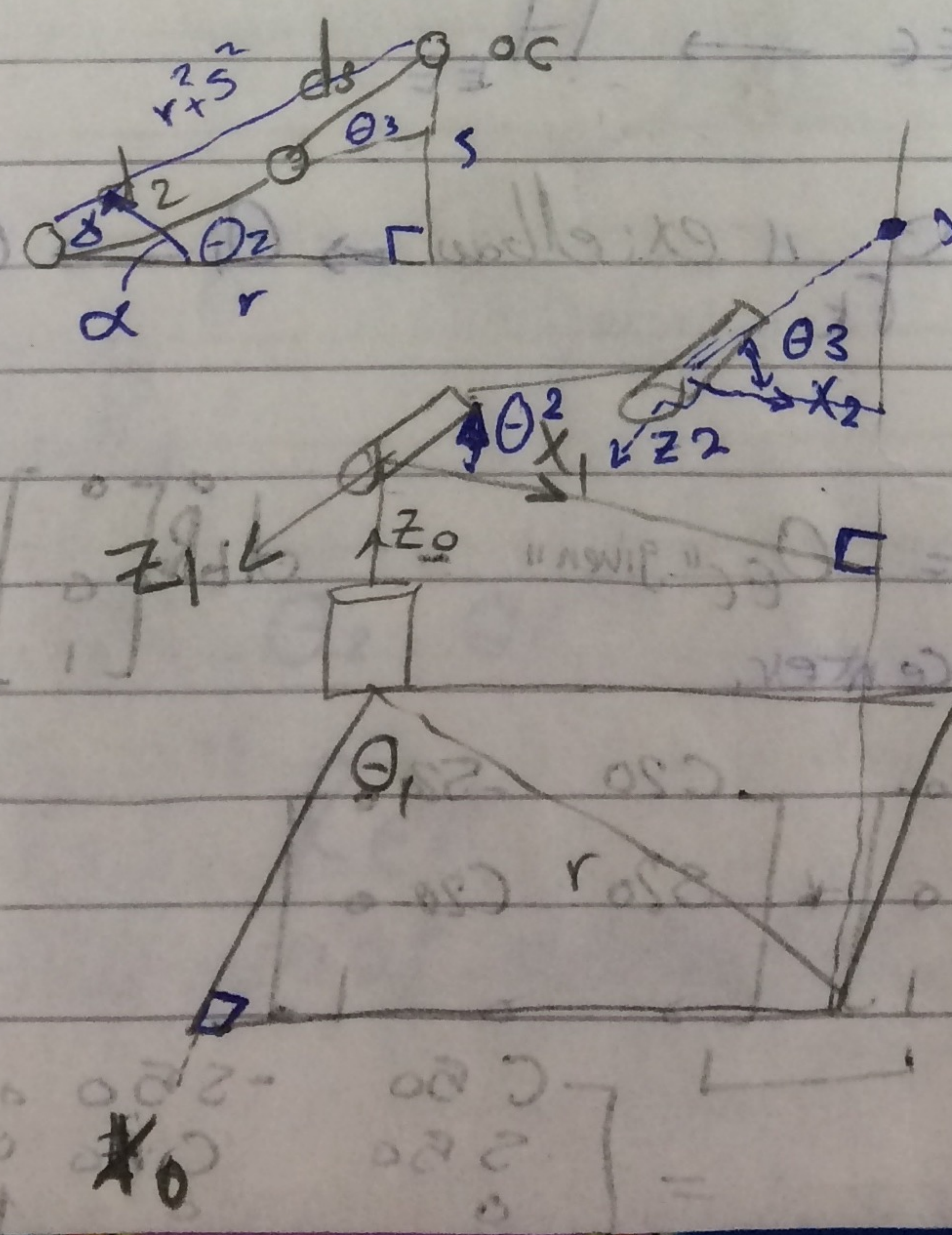
2- From Trigonometric eqn

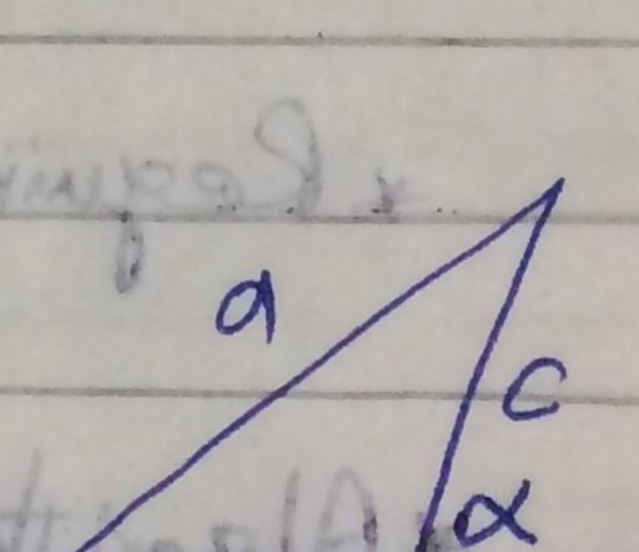
$\theta_1 = f_1(O_c)$

$\theta_2 = f_2(O_c)$ $\quad z_c, y_c, x_c$ لأن هم لينا معروفة

$\theta_3 = f_3(O_c)$

عند النظر من مستوى موازي للمستوى





$$\cos\alpha = \frac{b^2 + c^2 - a^2}{2bc}$$

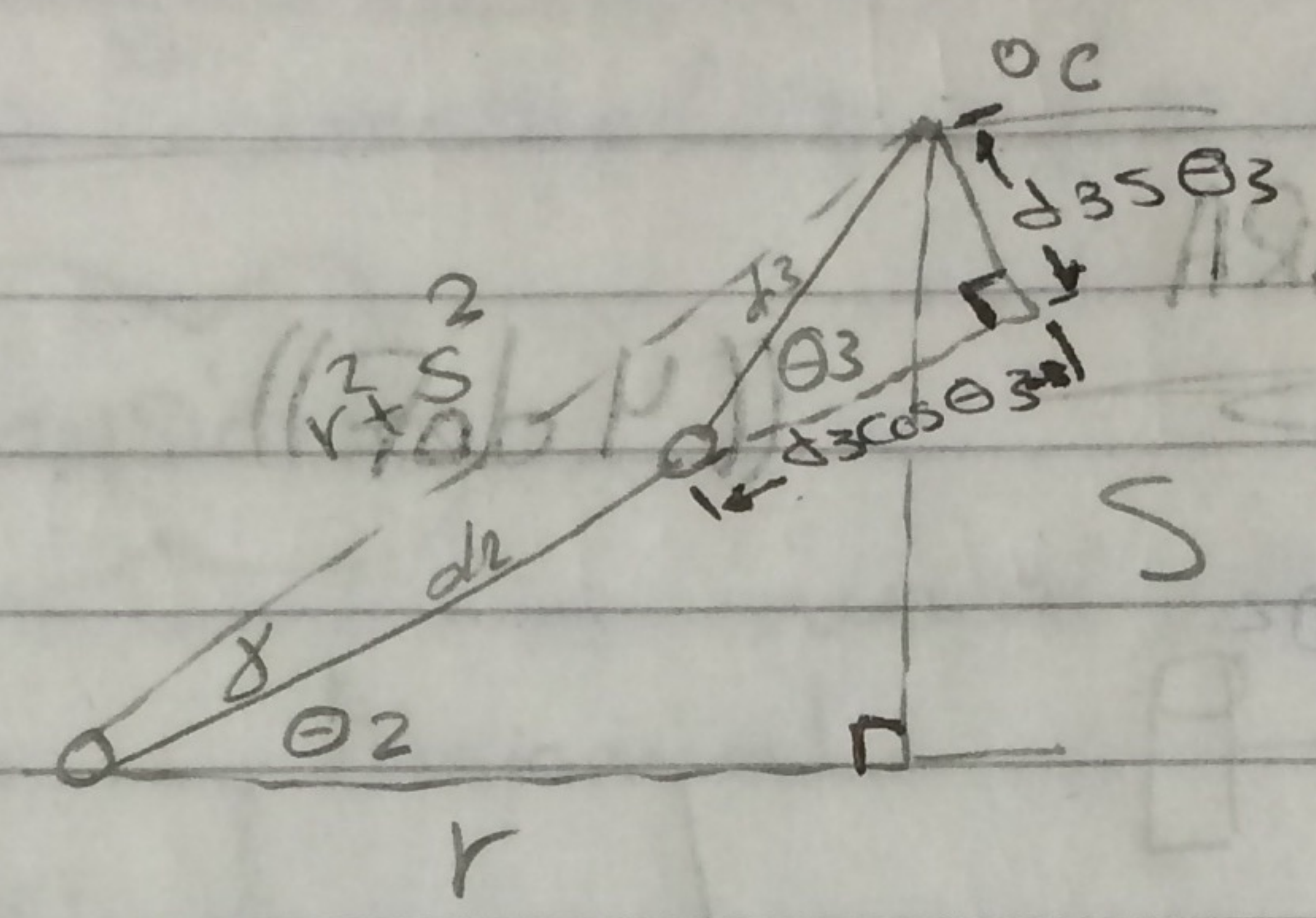
$$\theta_1 = \tan^{-1}\left(\frac{y_c}{x_c}\right)$$

$$\theta_3 = \cos^{-1}\left(\frac{d_2^2 + d_3^2 - (x_c^2 + y_c^2 + (z_c - d_1)^2)}{2 * d_2 d_3}\right)$$

$\theta_2 =$

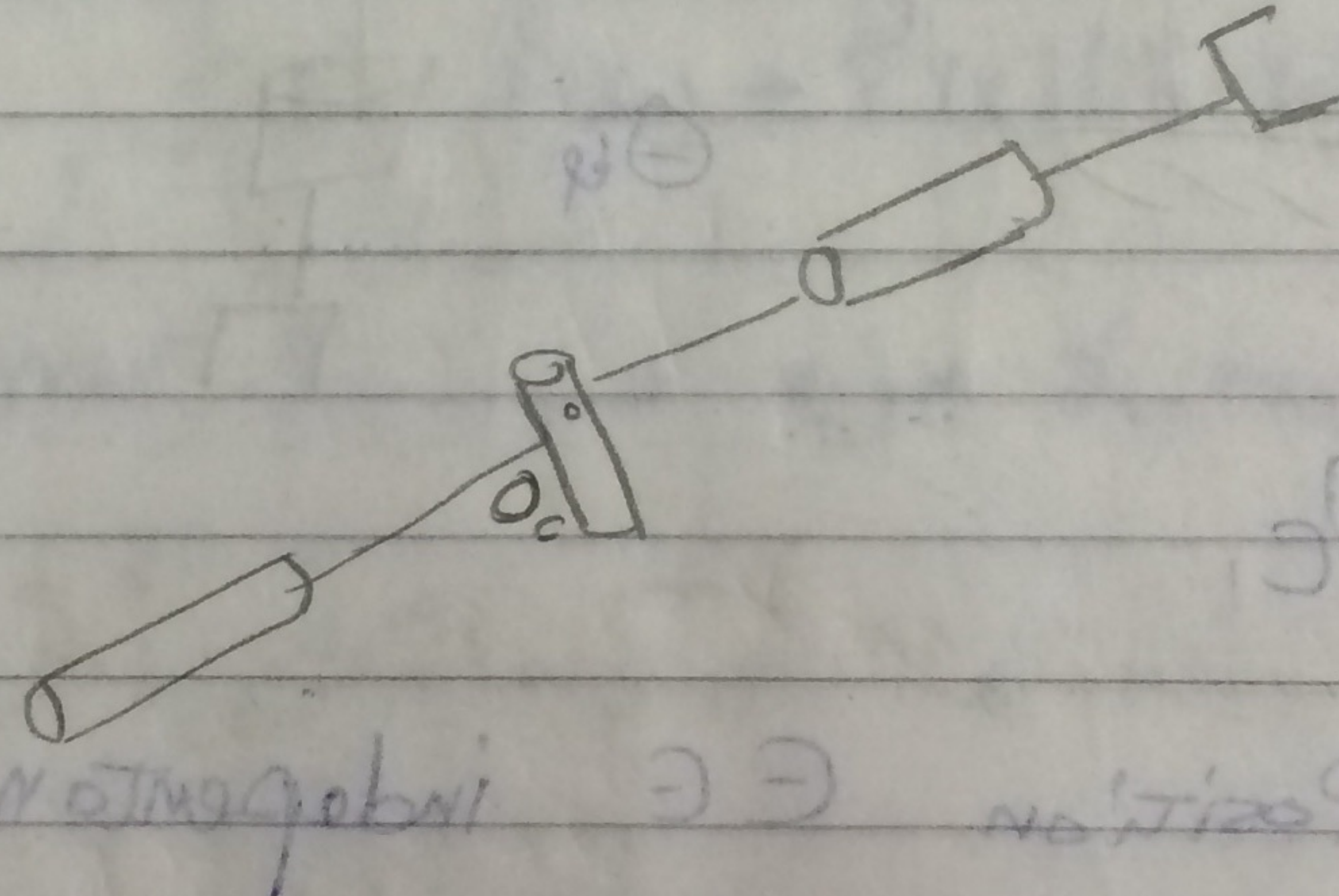
$$\alpha = \tan^{-1}\left(\frac{S}{r}\right)$$

$$\gamma = \tan^{-1}\left(\frac{d_3 S\theta_3}{d_2 + d_3 C\theta_3}\right)$$



3- orientation.

desired
- θ_4
- θ_5
- θ_6



$$R_{EE} = {}^0R_3 \, {}^3R_6$$

${}^0R_3$: from $\theta_1, \theta_2, \theta_3$

${}^3R_6$: $[{}^0R_3]^{-1} R_{EE}$

↳ spherical wrist orientation → Euler Angles.

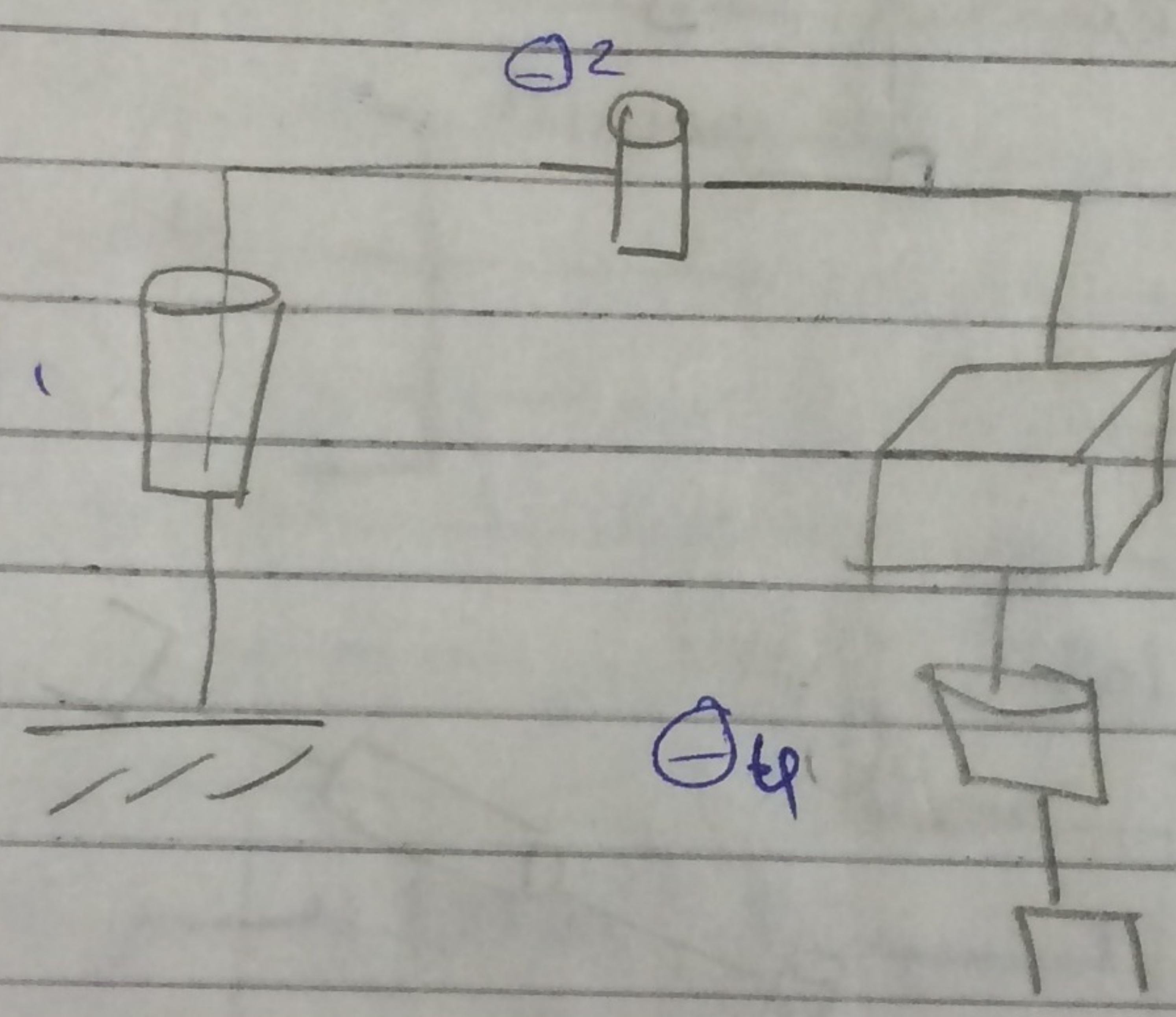
From ${}^3R_6$ using Euler parametrization: $\theta_4, \theta_5, \theta_6$

Euler matrix $\begin{bmatrix} & \\ & \end{bmatrix}$

θ, ϕ, ψ

$\theta_4, \theta_5, \theta_6$

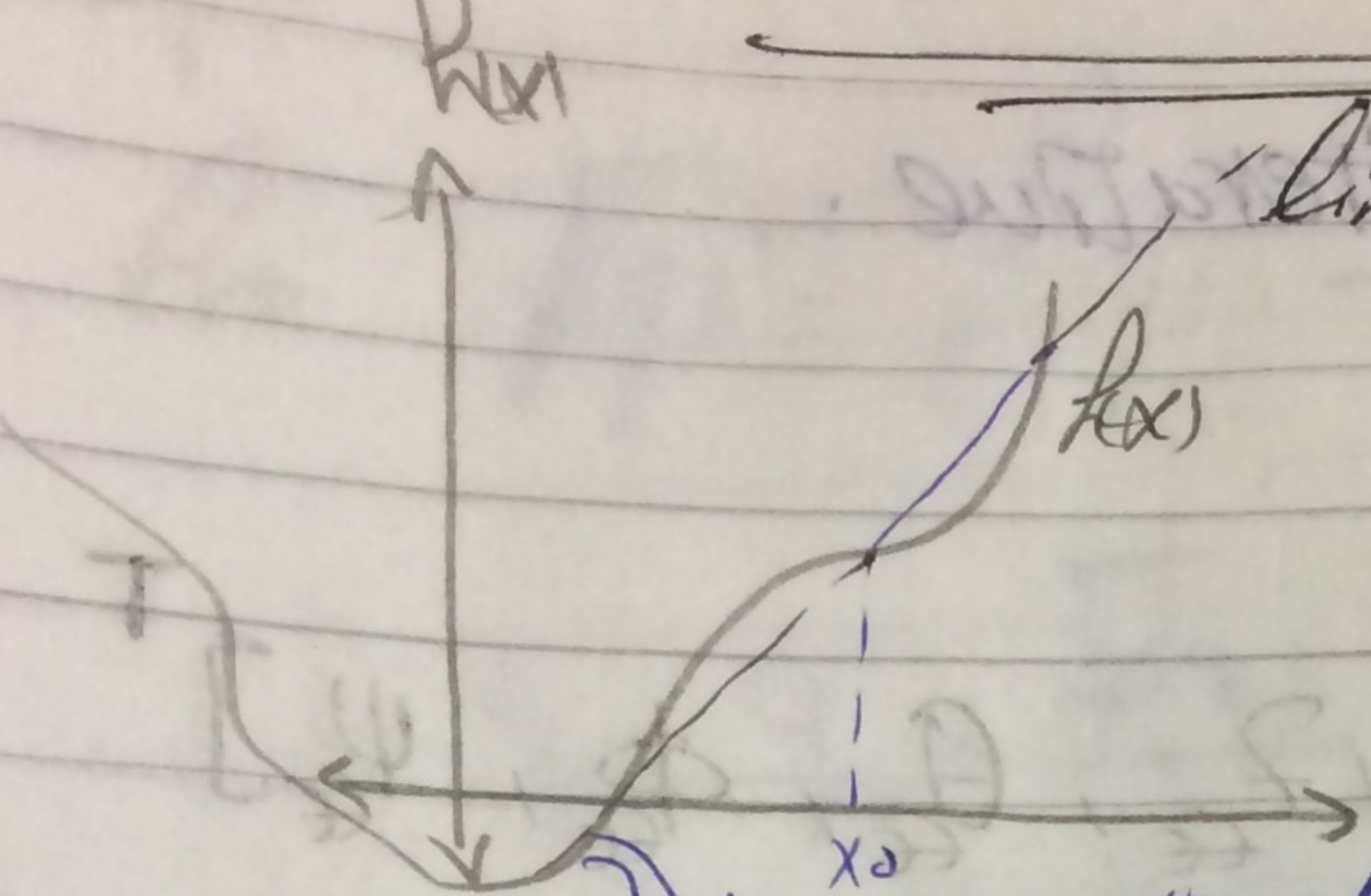
SCARA ((4 dof))



$\theta_{EE} = \theta_C$

Position EE indepent on θ_4

Numerical Methods



linear approximation of $f(x)$

التقريب الخطي لـ $f(x)$.

wanted to obtain x that make $f(x)=0$

Tylor expansion

أي داله نقدر نعبر عنها بحدود من binomial.

fns 1 order
fns 2^{nd} order.
⋮

$$\underbrace{f(x)}_{\text{Linear}} = f(x_0) + f'(x_0)(X - X_0)$$

كل ما يزيد X_0 range يزيد الـ error .

كل ما نقترب من X_0 يكون التعبير أكثر دقة .

$f_x \Big|_{\text{linear}} = 0$ ه

$$0 = f(x_0) + f'(x_0)(\underbrace{X}_{\text{root}} - X_0)$$

$$-f(x_0) = f'(x_0)(X - X_0)$$

$$X - X_0 = -\frac{f(x_0)}{f'(x_0)} = \boxed{X = X_0 - \frac{f(x_0)}{f'(x_0)}}$$

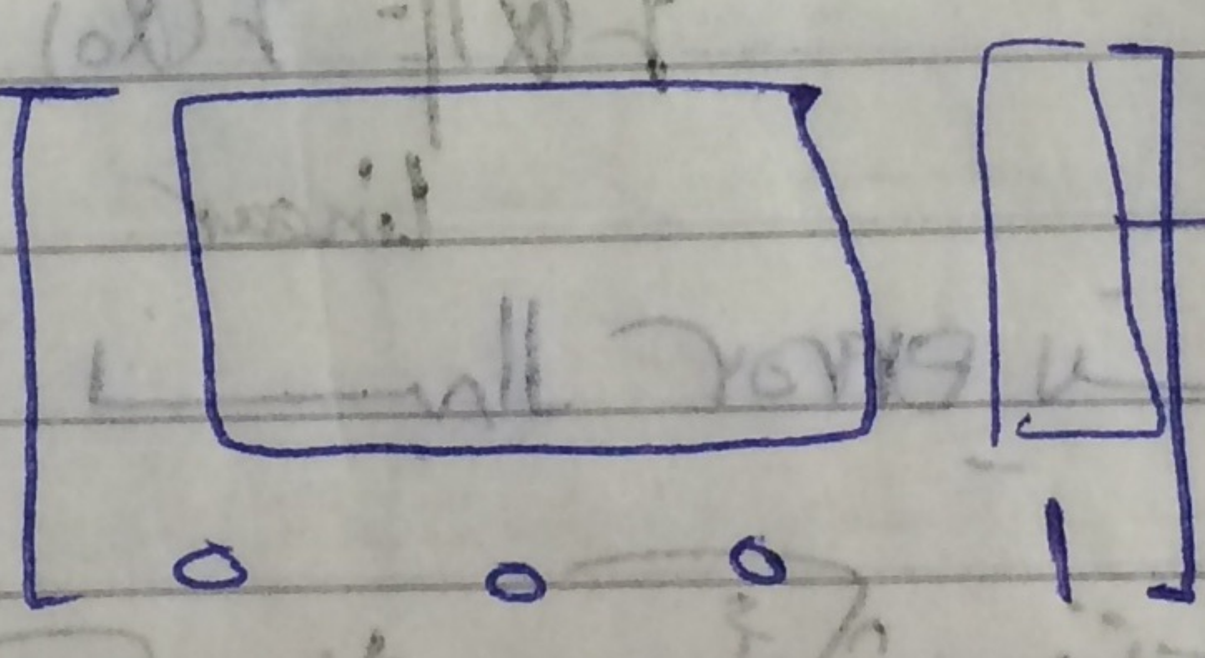
$$\boxed{x = x_0 - \frac{f_{x_0}'}{f'(x_0)}}$$ iterative.

given vector $g\,(x_{EE}, y_{EE}, z_{EE}, \theta_{EE}, \phi_{EE}, \psi_{EE}]^T$

desired pose

N (DoF) robot: $q_i \rightarrow i = 1, \ldots N$

$$f(q_k) = \begin{bmatrix} f_1\, q_k \\ f_2\, q_k \\ \vdots \\ f_6\, q_k \end{bmatrix}$$ from forward kinematics.



→ position of end effector

4x4.

كلهم الزوايا او بس

$f(\theta_{EE}, \phi_{EE}, \psi_{EE})$

6 non linear fns → كل واحده بتعرّف احد parameters

- o/p required parameters
- i/p 6 parameters of end effector g

Steps.

let $F(q) = f(q) - J$ $= 0$ at the desired pose

$$q = q_0 - \frac{F(q_0)}{F'(q_0)}$$

$$\frac{\partial F_1}{\partial q} = \frac{\partial F_1}{\partial q_1} + \frac{\partial F_1}{\partial q_2} + \cdots + \frac{\partial F_1}{\partial q_n}$$

$$\vdots$$

$$\frac{\partial F_n}{\partial q} = \cdots + \frac{\partial F_n}{\partial q_n}$$

multi f^ns of multivariable ديون

$$\frac{\partial f(q)}{\partial q} = \begin{bmatrix} \frac{\partial f_1}{\partial q} \\ \vdots \\ \frac{\partial f_6}{\partial (q)} \end{bmatrix} = \begin{bmatrix} \frac{\partial f_1}{\partial (q_1)} + & \cdots & \frac{\partial f_1}{\partial (q_n)} \\ \vdots & & \vdots \\ \frac{\partial F_r}{\partial (q_1)} + & \cdots & + \frac{\partial F_r}{\partial (q_n)} \end{bmatrix} \begin{bmatrix} F_1(q) \\ F_2(q) \\ \vdots \\ F_r(q) \end{bmatrix}$$

Jacobian

اكتر من F^{ns} ع متغير واحد

داله واحده ف اكتر من متغير

$$q_{r_{n\times1}} = q_{r_{n\times1}} - \underbrace{\cancel{\left(F(q_r)\right)^{-1}}}_{n\times6} F(q_r)_{6\times1}$$

$$\cancel{\left(F^{-1}(q)\right)}$$

only hor squar matrix ← inverse

pseudo-inverse

Artificial intelligence

$$q_r \longrightarrow \boxed{\quad} \longrightarrow f(q_r)$$

$q_1, q_2, --- q_n$ forward Kinematics $x_{EE}, y_{EE}, z_{EE}, \theta_{EE}, \phi_{EE}, \psi$

pose1

⋮

Try rangesfor q_r

1- drive forward Kinematics.

2- Try ranges of q and we obtain same Pose

" dataset of "
pose

3- Supervised learning "PSO"

list of poses → NN ANFIS → labeled output list of q

Polynomial Regrission

supervised learning

* we here ne dineet dataset

" Trained NN"

$\underline{NN}$ ↳ neural networkn

desired Pose → Trained NN. → required q